EXHIBIT 22

PNEUMATIC SYSTEMS

Principles and Maintenance

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Pneumatic Cylinders and Air Motors

SYNOPSIS

Pneumatic cylinders offer a straight rectilinear motion to mechanical elements. Cylinders are classified as light, medium, and heavy duty with respect to their application. Selection of materials for cylinder component depend greatly on this factor. Functionally, cylinders may be single acting and double acting. They may be further classified as diaphragm cylinder, duplex cylinder, through rod cylinder etc. End position cushioning of cylinders at certain times may be of utmost importance. However, if the cylinders do not travel up to the end of stroke, designers need not go for cushioned cylinders. The piston rod of cylinders are given special treatment as it is the highly stressed part. For cylinder lubrication, mist lubrication is most common. To generate rotary motion, air motors may also be used. Vane type motors are more popular. Air motors have certain specific advantages over electrical motors. Proper maintenance of cylinders, motors, and various air operated hand tools enhance their life expectancy to a great extent.

5.1 TYPES OF CYLINDERS

The pneumatic power is converted to straight line reciprocating motions by pneumatic cylinders. The various industrial applications for which air cylinders are used can be divided dutywise into three groups—light duty, medium duty and heavy duty. But according to the operating principle, air cylinders can be sub-divided as (i) single acting and (ii) double acting cylinders.

Single Acting Cylinder In a single acting cylinder, the compressed air is fed only in one side. Hence, this cylinder can produce work only in one direction. The return movement of the piston is effected by a built-in spring or by application of an external force. The spring is designed to return the

piston to its initial position with a sufficiently high speed. A single acting cylinder is illustrated in Fig 5.1(a).

5.1.1 Construction of Single Acting Cylinder

Generally, a single acting cylinder is made of the following elements: (i) the cylinder body (tube), (ii) two end covers (one may be an integral part of the

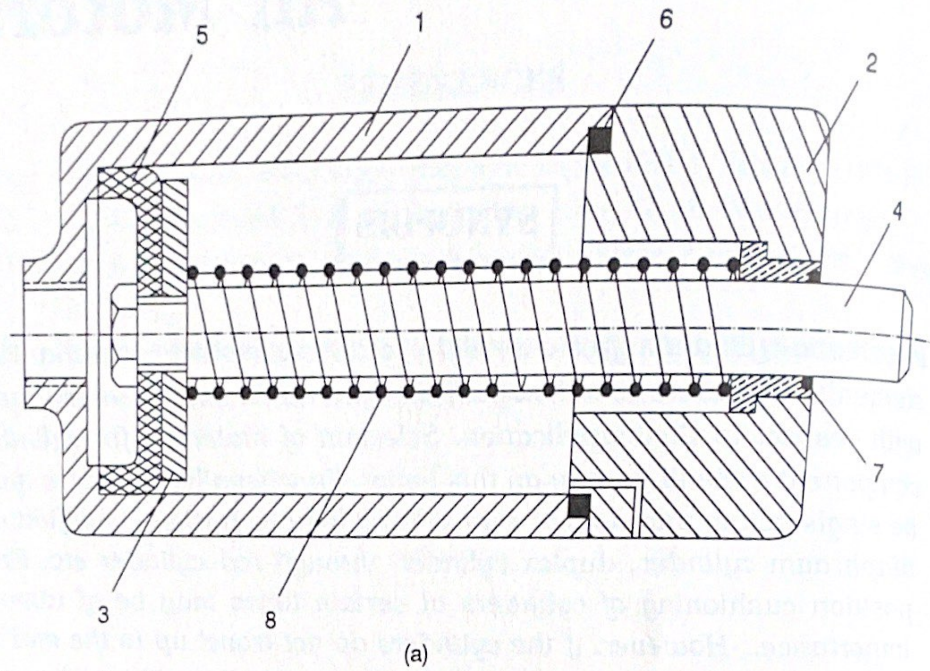

Fig. 5.1(a) Single acting cylinder: 1. Cylinder body (tube) 2. End cover 3. Piston 4. Piston rod 5. U-cap seal 6. O-ring 7. Bush 8. Spring

cylinder tube), (iii) a piston, (iv) piston rod, (v) U-cup seal, (vi) O-ring, (vii) bush or bearing to guide the piston rod, (viii) built-in spring. The end covers are fitted to the body by four cover screws or tie rods. An exploded view of a single acting cylinder is shown in Fig. 5.1(b).

In a single acting cylinder with spring, the stroke is limited by the compressed length of the spring. While the piston moves forward, there is possibility of the spring to bulge out and scratch the finely finished piston-rod surface, thereby damaging it. The air has to first overcome the pressure of the spring and hence some power is lost before actual stroke of the piston starts. The spring returns the piston back to its initial position. The size of the spring will depend on the diameter and stroke length of the cylinder which means, for a bigger size of single acting cylinder, a heavier section of spring is to be used and hence more power is required to overcome the spring-pressure and also for a longer spring, the compressed length of the spring will also be bigger which means more loss of stroke length. Sometimes, for bigger size single acting cylinders, two concentric springs one above the other may be used. But considering the above points, it has been found that using a bigger single acting (SA) cylinder is quite uneconomical

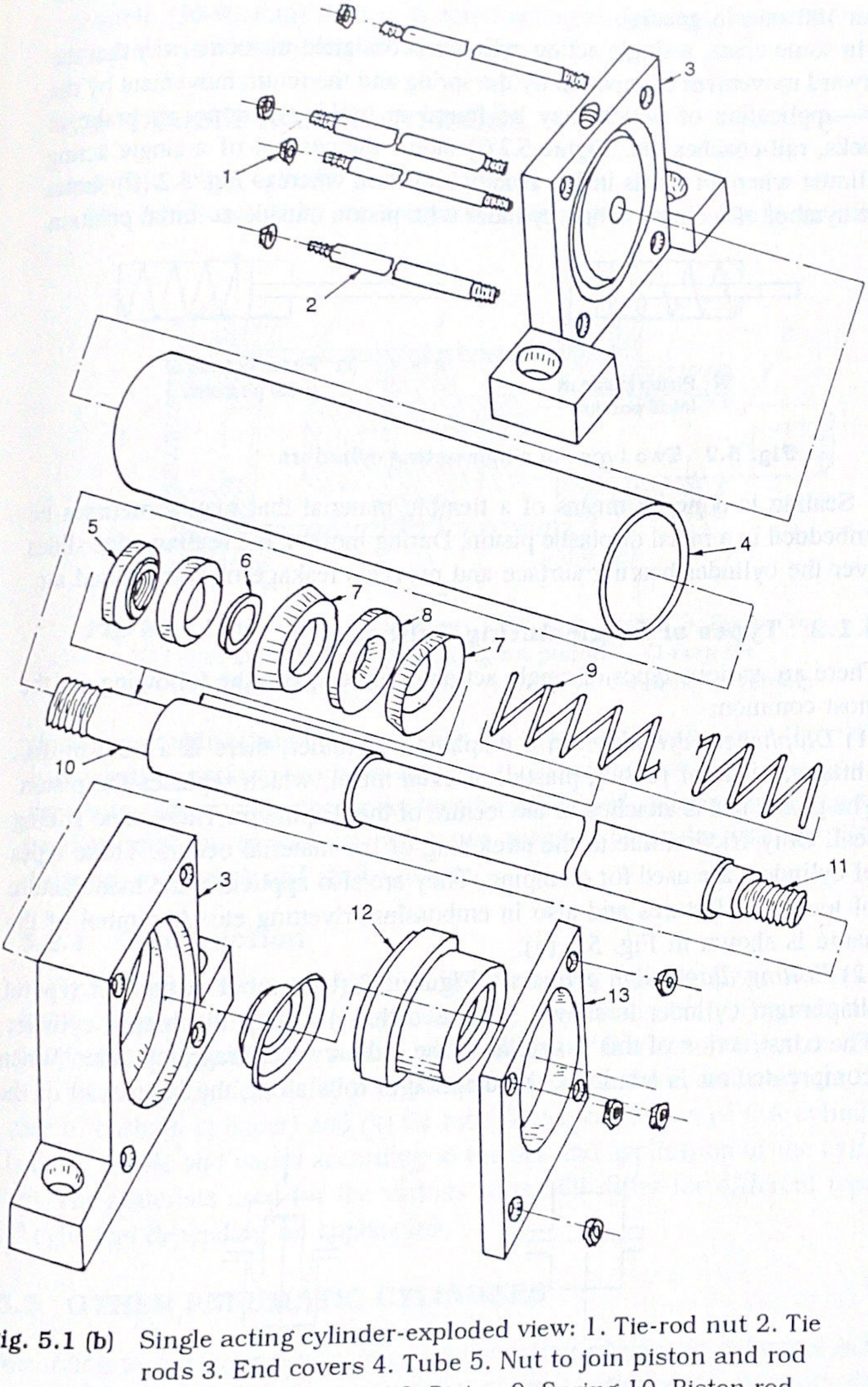

Fig. 5.1 (b) Single acting cylinder-exploded view: 1. Tie-rod nut 2. Tie rods 3. End covers 4. Tube 5. Nut to join piston and rod 6. O-ring 7. Cup seal 8. Piston 9. Spring 10. Piston rod 11. Threaded end of piston rod 12. Bush 13. Bush retainer

and, therefore, such a cylinder should not be used for a stroke length of more than 100 mm in general.

In some cases, a single acting cylinder is designed in such a way that the forward movement is imparted by the spring and the return movement by the air—application of which may be found in braking action—air brake in trucks, rail-coaches etc. Figure 5.2 (i) shows the symbol of a single acting cylinder where piston is inside at initial position whereas Fig. 5.2 (ii) shows the symbol of a single acting cylinder with piston outside at initial position.

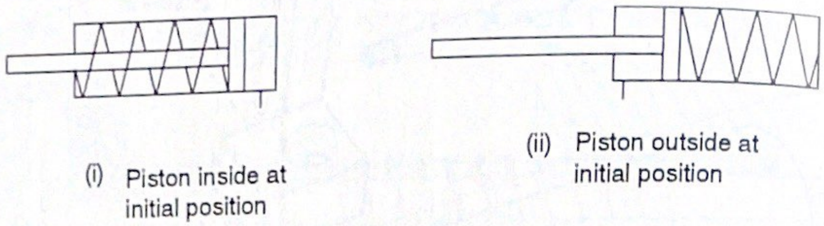

Fig. 5.2 Two types of single acting cylinders

Sealing is done by means of a flexible material that may sometimes be embedded in a metal or plastic piston. During motion, the sealing edge slides over the cylinder bearing surface and prevents leakage of compressed air.

5.1.2 Types of Single Acting Cylinders

There are various types of single acting cylinders. But the following are the most common:

(1) *Diaphragm cylinder* In a diaphragm cylinder, there is a built-in diaphragm, made of rubber, plastic, or even metal, which replaces the piston. The piston rod is attached to the centre of the diaphragm. There is no sliding seal. Only friction due to the stretching of the material occurs. These types of cylinders are used for clamping. They are also applied in the manufacture of tools and fixtures and also in embossing, rivetting etc. A symbol of the same is shown in Fig. 5.3 (a).

(2) *Rolling diaphragm cylinder* Figure 5.3 (b) symbol of another type of diaphragm cylinder is shown. This is called a rolling diaphragm cylinder. The construction of this is similar to the ordinary diaphragm cylinder. When compressed air is admitted, the diaphragm rolls along the inner wall of the

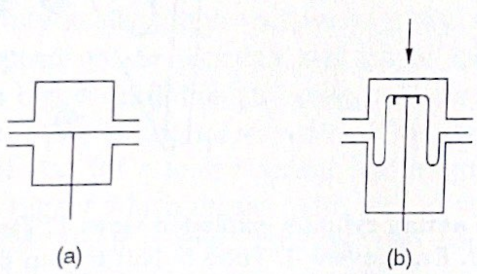

Fig. 5.3 (a) Symbolic representation of diaphragm cylinder
(b) Rolling diaphragm cylinder

cylinder and moves the piston rod outwards. A considerably larger stroke is possible (50-80 mm) than with the diaphragm cylinder. Furthermore, the friction is conderably less in this design.

5.2 DOUBLE ACTING CYLINDER

A double acting cylinder is shown in Fig. 5.4.

The force exerted by the compressed air moves the piston in two direc-

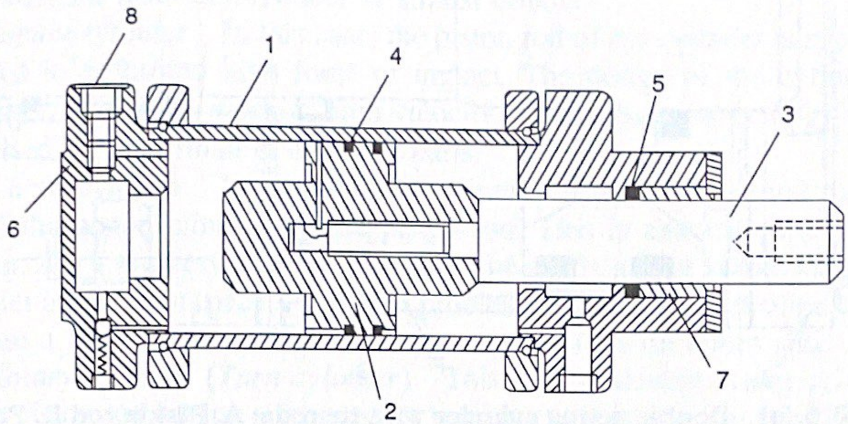

Fig. 5.4 Double acting cylinder: 1. Tube 2. Piston 3. Piston rod 4. Double O-ring packing on piston 5. O-ring for piston rod 6. End cover 7. Bush 8. Cushion assembly

tions in a double acting cylinder. They are used particularly when the piston is required to perform work not only on the advance movement but also on the return. In principle, the stroke length is unlimited, although buckling and bending must be considered before we select a particular size of piston diameter, rod length and stroke length.

5.2.1 Construction

In Fig. 5.5 (a), a different design of double acting cylinder (DA) is shown. A DA cylinder consists of (i) cylinder tube, (ii) piston unit, (iii) piston rod, (iv) double cup packing on piston, rod packing of 'O' rings, (vi) end covers, (vii) bronze rod guide, (viii) port connection, (ix) cushion-assembly (in the case of cushion cylinder) and (x) tie rods. The construction of DA cylinder is quite simple and varies according to the use and application of the cylinder. The materials used for the various parts will differ for different types of cylinders depending on application.

5.3 OTHER PNEUMATIC CYLINDERS

According to operational principle, double acting pneumatic cylinders may be divided into the following types. Some of these cylinders are symbolically represented in Fig. 5.5(b).